Low-Temperature Handling of Sterilized Foods. IV

Color and Flavor of Canned Vegetables[a]

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SUMMARY

Effects of processing methods on flavor and color attributes indicate that HTST processing was generally superior to conventional processing and was comparable to or better than frozen storage immediately after the processing. Retention of the advantage was dependent on storage time and temperature. If the storage temperature was maintained at 35–50°F, the HTST samples were preferable to conventional samples for 24 months, and comparable to or better than the frozen samples in all attributes except hue. At 25 and 85°F, however, the retention of favorable color and flavor attributes rapidly diminished. Flavor degradation was most noticeable in storage at 85°F. Of the products examined, whole-kernel corn appeared best suited for HTST processing.

IN RECENT YEARS, high-temperature short-time sterilization (HTST) of foods has become an increasingly important factor in thermal processing. Several papers are concerned with the application of HTST sterilization processes (Anon., 1948; Clifcorn *et al.*, 1950; Epstein and Ball, 1960; Havighorst, 1953; Morgan, 1960; Vetter *et al.*, 1957), and patents have been granted for HTST equipment. This series of papers discusses biochemical factors (Brody *et al.*, 1960) and color (Epstein *et al.*, 1960) of certain HTST-sterilized products; however, the general areas of palatability and appearance have been largely neglected. To evaluate the effects of HTST sterilization on these quality aspects, and in particular to evaluate the effects of low-temperature storage on HTST-sterilized food, an extensive study was undertaken of the hue, brightness, flavor difference, and flavor preference of several products.

This paper summarizes color and flavor comparisons of HTST, frozen, and conventionally canned vegetables, evaluated throughout a 24-month storage period. The results are compared with those previously reported on biochemical factors (Brody *et al.*, 1960).

EXPERIMENTAL PROCEDURE

The products evaluated were green peas, whole-kernel corn, asparagus, and green beans. Preparation, canning, and thermal processing have been described (Brody *et al.*, 1960; Epstein and Ball, 1960; Epstein *et al.*, 1960). Table 1 lists the process times and retort temperatures. The HTST samples were packed in 211 × 011 plain cans, whereas conventionally processed and frozen samples were packed in 211 × 300 plain cans. Samples of HTST and conventionally processed products were stored at 25, 35, 50, and 85°F. All samples were evaluated immediately after processing and after 3, 6, 12, 18, and 24 months of storage. The frozen samples were stored at 0°F.

Color evaluations were made with a Gardner Color Difference Meter. Measurements were recorded for L, a_L and b_L, from which were determined hue values ($\tan^{-1} a/b$) and brightness (L). Table 2 lists the standard plates used for evaluation of each product. Three replicates, each containing the solid contents of two cans, were used for analysis of color of conventional and frozen samples; six cans were used for HTST samples.

Table 1. Processing conditions for HTST and conventionally canned vegetables.

Product	Retort temperature (°F)		Heating time		Cooling time	
	HTST	Conv.	HTST (sec)	Conv. (min)	HTST (min)	Conv. (min)
Green peas	300	250	70	15	5	15
Green beans	300	245	60	15	5	15
Asparagus	300	240	65	27	5	15
Whole-kernel corn	300	245	66	40	5	15

The procedure used for flavor-difference analysis was based on methods described by Mahoney *et al.*, 1957. The multiple-comparison technique presented in that article was used with the following change: The "acceptable or not acceptable" choices were replaced by "better than, comparable to, or poorer than" the check sample. For this reason the two-panel test was changed to a twenty-member three-panel test. Duplicates of each sample were tasted at two of the three panel meetings. The check samples were conventionally processed, and stored at 35°F. Mean difference values and flavor preferences were determined for each of the nine samples (four storage temperatures each for HTST and conventional samples, and one storage temperature for frozen samples) with points 1–5 presented as none, slight, moderate, large, and extreme, respectively.

Table 2. Standard color plates for color evaluation of vegetables.

Product	National Bureau of Standards plate number	Values of standard plate		
		L	a_L	b_L
Green peas	12	55.7	−22.3	12.2
Green beans	15	58.2	−21.0	14.5
Asparagus	12	55.7	−22.3	12.2
Whole-kernel corn	35	73.4	1.0	31.7

Explanation of Tables 3 to 6. In section A, Processing Method includes HTST, conventional, and frozen methods.

The length of storage time in months, which was considered for Section C, can be seen in the storage time analysis (section D).

Joined circles indicate significant differences at the 5% level. Dotted lines indicate no significant difference.

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RESULTS AND DISCUSSION

Color changes due to processing and storage. The results of statistical analysis of color attributes are presented in Tables 3–6. These analyses show statistical differences but do not indicate which treatment produced the most desirable effect. Preference of color attributes is presented here on the basis of similarity to the original material, i.e., rated as preferable are the hue values that agreed most closely with those of the original, unprocessed material.

Of the two color attributes evaluated, the hue values were more affected by processing, storage temperature, and storage time than were the brightness values. The highest correlation with both color attributes was shown by storage time. Processing method showed a medium degree of correlation, and storage temperature a very low one.

The hue values were maintained best in frozen storage. Generally, the desirable greenness or yellowness was appreciably higher in the frozen samples than in the HTST or conventional samples. HTST processing was considerably better for retention of hue than conventional processing. The interaction of storage time with method of processing was particularly noticeable here. HTST samples appeared to retain a desirable hue in some measure for 6–12 months of storage, whereas conventional samples generally deteriorated to a noticeable extent within the first three months.

The retention of brightness was most favorable for HTST samples. In particular, the brightness values were considerably higher in HTST whole-kernel corn than in frozen or conventional samples. Frozen samples retained their brightness values for longer periods than did conventional samples, but for shorter periods than did HTST samples.

For both HTST and conventional samples, the effects of storage temperature on hue values were noticeable only between samples stored at 25°F and those stored at 85°F, and there were no significant effects of storage temperature on brightness values. Samples stored at 25°F retained the characteristic hue for 3–6 months, whereas samples stored at 85°F had, after 3 months of storage, hue values significantly different from the initial values.

Flavor changes due to processing and storage. The flavor analysis is based primarily on evaluations of differences rather than on preferences. Difficulty was encountered in judging preference between processes with a taste panel of twenty members. Differences are invariably recognized between HTST, conventional, and frozen samples; however, the preference displayed for a particular sample is frequently split between better-than reference and poorer-than reference.

For example, with whole-kernel corn stored for 6 months, all panel members recognized the differences between HTST, frozen, and conventional samples. One-third of the panel members preferred HTST samples to the conventional samples, one-third rated the HTST samples poorer than the conventional sample, and the remaining third recognized a difference in the flavor of the samples but rated the HTST as comparable to the conventional samples on the preference scale. Reaction to frozen samples was the same.

This anomaly in preference rating can best be classified as a matter of "flavor environment" of panel members, and since this study is primarily in food science rather than psychology, flavor preference is reported only where indications for its presentation are clear.

Table 3. Color of green peas.

A. Significant effects of treatments

Treatment	Brightness signif. level (%)	Hue signif. level (%)
Process	....	1.0
Storage temperature	....	5.0
Storage time	0.1	0.1

B. Multiple comparison of processing method (mean values)

Method	Hue signif. diff.	Rank
HTST		2
Conventional		3
Frozen		1

C. Multiple comparison of storage temperature (mean values)

Storage temperature (°F)	Hue signif. diff.
25	
35	
50	
85	

D. Multiple comparison of storage time (mean values)

Storage time (months)	Brightness signif. diff.	Hue signif. diff.
0		
3		
6		
12		
18		
24		

Table 4. Color of whole-kernel corn.

A. Significant effects of treatments

Treatment	Brightness signif. level (%)	Hue signif. level (%)
Process	0.1	5.0
Storage temperature	....	....
Storage time	0.1	0.1

B. Multiple comparison of processing method (mean values)

Method	Brightness signif. diff.	Rank	Hue signif. diff.	Rank
HTST		1		1
Conventional		3		2
Frozen		2		3

C. Multiple comparison of storage time (mean values)

Storage time (months)	Brightness signif. diff.	Hue signif. diff.
0		
3		
6		
12		
18		
24		

Table 5. Color of green beans.

A. Significant effects of treatments

Treatment	Brightness signif. level (%)	Hue signif. level (%)
Process	0.1	0.1
Storage temperature	....	1.0
Storage time	5.0	0.1

B. Multiple comparison of processing method (mean values)

Method	Brightness signif. diff.	Rank	Hue signif. diff.	Rank
HTST	●	1	○	2
Conventional	○ ○	2	○ ○	3
Frozen	○	1	○ ○	1

C. Multiple comparison of storage temperature (mean values)

Storage temperature (°F)	Hue signif. diff.
25	○
35	○
50	○
85	○

D. Multiple comparison of storage time (mean values)

Storage time (months)	Hue signif. diff.
0	○
3	○
6	○
12	○
18	○

Differences in flavor due to process method were significant immediately after processing and throughout storage. The differences between HTST samples and the check were less noticeable than between frozen samples and the check, and conventional samples were initially rated as similar to check (as expected since the check sample was conventionally processed). The difference values indicated for frozen samples diminished through storage, but remained higher than HTST difference values in all cases (Table 7).

Table 6. Color of asparagus.

A. Significant effects of treatments

Treatment	Brightness signif. level (%)	Hue signif. level (%)
Process	....	5.0
Storage temperature	....	....
Storage time	0.1	0.1

B. Multiple comparison of processing method (mean values)

Method	Hue signif. diff.	Rank
HTST	○ ○	3
Conventional	○ ○	2
Frozen	○ ○	1

C. Multiple comparison of storage time (mean values)

Storage time (months)	Brightness signif. diff.	Hue signif. diff.
0	○	○ ○
3	○	○
6	○	○ ○
12	○ ○	○ ○

The preference for HTST samples was higher than for frozen samples immediately after processing, and generally continued for 3–6 months. After 6 months of storage, however, HTST samples were rated as poorer than the check whereas there was no preference difference between frozen and conventional samples after 12 months.

The effects of storage temperature on flavor differences were more noticeable for conventional samples than for HTST samples. However, HTST samples stored at 35 and 50°F were rated as preferable to the check up to 6 months of storage, and those stored at 85°F were rated as poorer than the check after 3 months of storage. Differences between HTST samples due to storage temperature were negligible after 6 months.

Table 7. Mean hedonic-scale ratings for effects of processing methods on the flavor of vegetables.

Product	Storage time (months) 0	3	6	12	18	24
Green peas						
HTST	3.75	4.36	3.01	3.10	3.02	3.34
Conv.	1.86*	2.36*	2.02	2.33*	1.94*	1.73*
Frozen	5.27	5.07	4.57	4.39	4.81	NA
Green beans						
HTST	3.50	3.29	3.87	3.88	3.67	3.06
Conv.	1.43*	1.78*	2.00	2.01*	1.43*	1.35*
Frozen	4.55	4.65	4.59	5.69	4.79	4.05
Whole-kernel corn						
HTST	3.81	3.66	4.44	3.73	3.47	4.14
Conv.	2.28*	2.44	2.29	2.43	1.92*	2.25*
Frozen	3.97	4.77	4.70	4.32	3.69	NA
Asparagus						
HTST	3.04	3.66	2.63	3.23	3.02	3.99
Conv.	2.04*	2.15*	1.60*	2.01*	1.70*	3.16
Frozen	3.55	4.38	3.53	3.75	NA	NA

* Not significantly different from check at the 0.1% level.

The effects of storage temperature on flavor of conventional samples were most noticeable between samples stored at 25°F and the check, and those stored at 85°F and the check. The 85°F samples deteriorated rapidly in flavor after 3 months, whereas the 25°F samples showed only slightly poorer flavor than the check throughout the storage period. Conventional samples stored at 35 and 50°F exhibited optimum flavor retention.

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